JPL CONTRACT NUMBER 951492

STERILIZABLE ACCELEROMETER

FOURTH QUARTERLY TECHNICAL REPORT

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INTRODUCTION

Besides covering the work accomplished during the fourth quarterly reporting period, this report summarizes the activity of the first three quarterly reporting periods, thus representing a review of the tasks performed during the first year of the contract.

The following abstract is restricted to the work performed during the fourth reporting period.

ABSTRACT

Accelerometer M-225 was rebuilt with new springs whereby the Scotchweld EC-2258 was again applied in the spring-to-support joints. The flip-flop soak tests resulted in a bandwidth of 255 micro g before temperature sterilization and 453 micro g after temperature sterilization, which is the best result obtained so far in this program.

During the experimentation with accelerometer M-225 prior to its rebuilding, the pendulum showed signes of sticking to the capacitance rings. During reassembly after cleaning of the instrument the springs were accidentally broken, which caused a severe schedule setback. An assembly procedure allowing surface protection to be applied to the capacitance rings was experimentally applied. Electroless goldplating appears promising.

Temperature sterilization caused the failure of electronic assembly E7 which was attached to mechanical assembly M-225. This electronic assembly is of original design. The collector resistor and the transformer were found damaged.

Progress was made in the building of transformers and electronic assemblies designed to meet the temperature sterilization environment.

Unexpected difficulties with the variable capacitors showed up already under standard application conditions not involving temperature sterilization. None of the four will be used in this program.

SCOPE

In a general manner, it can be stated that the effort was concentrated on making the accelerometer resistant to the temperature sterilization environment. Ethylene oxide compatability was not considered for any component contained within the outer shell of the accelerometer, which is to be hermetically sealed. This applies specifically to the mechanical sensing system and to the electronic assembly. Nickel plating will be applied for surface protection of the outer surfaces of the accelerometer where required.

DETAILS

In the following, reference will frequently be made to the first three quarterly technical reports. The following abbreviations will be used:

Qu.R.1 For the first quarterly technical report, Bell Report Number 60007-026.

Qu.R.2 For the second quarterly technical report, Bell Report Number 60007-207.

Qu.R.3 For the third quarterly technical report, Bell Report Number 60007-028.

1. General Design

Reference is made to Qu.R.1, pages 18 through 21.

1.1 Accelerometer Envelope

The envelope of the deliverable accelerometer is defined by drawing 26-01290 representing the Model VIIB-16, which is especially designed for hermetic sealing. No reasons for deviation from this envelope have come up during the program.

1.2 Pendulum Design

As explained in section 3.2 of Qu.R.1, Bell proceeded in this program with a composite aluminum pendulum design. The coilforms used in the experimentation were supplied with outer grooves allowing direct winding of the torquer coil on the coilform. It is intended to apply this design in the deliverable accelerometer rather than to return to the monolithic beryllium pendulum. The bias stability obtained after temperature sterilization with the experimental accelerometer of latest configuration is not considered satisfactory, but it is felt that the transition to the monolithic beryllium pendulum would not significantly improve the bias stability at this stage of development but, rather introduce new problems related to the inner groove structure of the monolithic pendulum. It appears that the critical area is the material used to bond the springs to the pendulum supports rather than the pendulum design.

1.3 Spring Constant K_s

No new inputs have come up during the investigation to establish the final value of K_s. An appropriate study is under way on a separate program.

1.4 Input Axis Alignment

See section 2 of this report.

2. Performance Requirements

According to Article 1, Section (a) (2) of the contract, the accelerometer, after sterilization, shall meet the following requirements:

(i)	Bias Error	±300 micro g maximum
(ii)	Bias Error Stability	100 micro g 1 σ
(iii)	Scale Factor	1 ma/g ± 10%
(iv)	Scale Factor Stability	.05% 1 σ
(v)	Input Axis Alignment	± 15 Arc Minutes
(vi)	Input Axis Stability	30 Arc Seconds 1 σ
(vii)	Frequency Response	That of a critically damaged second order system with a cutoff frequency not less than 300 cps.

At the outset of this investigation, it was known that a Model III B accelerometer of original design will not meet the requirements for the bias error and the bias error stability after being submitted to a temperature soak of about 120 hours at 200°F, a mild environment compared to that of temperature sterilization. After such a cure of 120 hours, at 200°F the Model IIIB accelerometers exhibited a bandwidth of 800 μg and more for the null bias return points following temperature soaks of 8 hours at 160°F.

It was felt at Bell that the performance of the Model VII accelerometer would not differ very much from that of the Model IIIB accelerometers and actual sterilization tests with the Model VII accelerometers of original design have not been conducted at Bell. Recent evaluations performed at JPL indicate a possible bandwidth of 1500 μg for the bias return points of standard Model VII accelerometers that have been subjected to temperature sterilization.

It was anticipated that the reduction of the bias bandwidth would be the most difficult task of the project.

No difficulties are expected in meeting the 1 ma/g ± 10% requirement for the scale factor. According to an agreement with JPL, the deliverable accelerometer will not be equipped with a temperature compensation network. It is therefore understood that the scale factor stability is to be determined from measurements taken at a selected reference temperature or that the values are to be reduced to take the effect of deviations of the actual temperature from the reference temperature into account. No difficulty is anticipated in meeting the scale factor stability requirement of .05% 1σ.

Concerning the input axis alignment and the input axis stability, reference is made to Qu.R.1, pages 20 and 21. As explained, the aximuth angle of the sensitive axis will not be measured and, therefore, the stability of this angle will not be determined. There is no difficulty in maintaining the angle between the sensitive axis and the seating surface of the mounting base within ± 15 arc minutes. Further, general experience shows that the variations of this angle, which is "built in", are small.

Meeting the frequency response requirement should not present a problem.

3. Mechanical Assembly

The environment of temperature sterilization has entailed investigations in two main areas:

First, the bond between the spring tabs and the pendulum supports. At the present stage of development, it is the resistance to the environment of temperature sterilization of this bond that primarily determines the bias stability of the accelerometer.

Second, the choice of nonmetallic materials in applications other than the spring-to-support bond. It is felt that here reliability is more involved than instrument performance. In accelerometers of original design deposits have developed under the influence of temperature sterilization and one of these deposits, of granular structure, has appeared in the magnetic airgap; it represents a potential reliability hazard. Some nonmetallic materials have shown signs of deterioration and replacement materials have been evaluated.

The investigation of the above named two main problem areas was performed independently and will accordingly be represented in the sections 3.1 and 3.2 of this report.

A third problem area, namely corrosion of the capacitance rings, which may or may not appear, is not directly connected to the temperature sterilization environment. Sticking of the pendulum to the capacitance rings in open loop operation has on occasion been observed in other programs. Minute white particles on the capacitance rings were observed and cleaning of the capacitance rings eliminated the sticking. Such sticking was observed after temperature sterilization of the experimental accelerometer M-225. (For reference, see section 1 of the tenth monthly technical progress report covering May 1967.) This incident prompted an investigation of applicable surface protection procedures. Details are given in section 3.3 of this report.

3.1 Spring-to-Support Bond

As mentioned in Qu.R.1, page 2, the bias stability of the accelerometer depends highly upon the bond between the spring tabs and the pendulum supports. Using controlled test conditions, referred to as flip-flop soak tests (see section 3.1.1.2 of this report) a measure for the bias stability can be established. This test method has so far been applied exclusively to accelerometers with adhesive spring-to-support bonds. In such experiments, conducted prior to the present investigation, it has been demonstrated that the bonding material used in standard accelerometers, namely LCA-4/BA-9 epoxy, does not withstand temperature sterilization. A major part of the present investigation has therefore been applied to the identification of more suitable bonding materials.

Although an improvement of the order of three to one has been achieved over the bias stability obtained with the LCA-4/BA-9 epoxy, to date no adhesive has been identified that is considered satisfactory. The possibility that this situation might arise was anticipated and some thoughts were spent on a method to completely avoid the use of an adhesive in the spring-to-support joints. An approach using electron beam welding or laser welding was outlined (for reference see: Proposal for Design of a Sterilizable Accelerometer, Bell Report Number 60002-440-1, Supplement Number 1, Pages 13 through 17). Because new techniques are involved, the present program provides only for preliminary investigation in the area of laser welding. This part of the effort is described in section 3.1.2 of this report.

The efforts to improve the adhesive bond from the springs to the pendulum support involved two kinds of activity carried out in parallel:

First, the pre-evaluation of adhesives.
Second, bond evaluation in functional accelerometers.

The pre-evaluation efforts are covered in section 3.1.1.1 of this report, the bond evaluation in functional accelerometers in section 3.1.1.2.

3.1.1 Adhesive Bond

3.1.1.1 Pre-evaluation of Adhesives

In previous programs efforts have been made to establish a correlation between the null bias stability of an accelerometer and the physical qualities of the bonding material qualities such as the coefficient of thermal expansion or the heat distortion temperature. These efforts proved unsuccessful.

In the present program some efforts were made to experimentally determine the heat distortion temperature of the adhesives under evaluation. The main emphasis in all other tests was, however, placed on experimentation involving the interaction of the adhesive with the materials used in the joints, namely beryllium copper, and aluminum. It was not expected that this experimentation would conclusively indicate, which adhesive would render the best bias stability in an accelerometer; it did, however, serve as a valuable guide in the selection of the adhesives to be evaluated in functional accelerometers. A certain correlation between the results of the pre-evaluation tests and the tests performed with actual accelerometers did emerge.

The following types of tests were performed:

Tests to determine the heat distortion temperature.

Wetting and bonding tests, including peel tests.

Shear tests.

It appears that the peel tests and the shear tests are most significant.

3.1.1.1.1 Heat Distortion Temperature

Bars of 2-3/8 inch length and 1/4 inch diameter were cast and cured according to vendor recommendations. The test provided for weighting of the bars under cantilever load in progressively rising temperatures. Permanent deformation of the bars was to constitute the criterion for heat distortion.

The weighting tests on bars made of EU-120 D epoxy were abandoned because of poor repeatability of the deformation measurements. For the same reason, the measurements on a bar made of Ablecast 147-1 epoxy were discontinued. In two other cases, the investigation was not carried beyond the point of the casting of the bars. The probes made of EC-1469 epoxy were extremely porous on their outer surfaces; indications are that they also contain small bubbles in the interior. In addition, curing difficulties were encountered. At this point the tests to determine the heat distortion temperature were dropped and also the decision made not to apply this type of epoxy in a functional accelerometer. Specimens made of the EC-2258 epoxy were found to be hollow inside over a length of about one inch. When vacuum was applied during the casting, the probes did not come out even and the attempts to determine the heat distortion temperature were dropped. The EC-2258 material was, however, applied in a functional accelerometer and rendered the best results obtained to date (See Section 3.1.1.2 of this report).

3.1.1.1.2 Wetting and Bonding Tests, Peel Tests

The following three types of adhesives were evaluated:

EC-1469	Minnesota Mining & Manufacturing Company
EC-2258	Minnesota Mining & Manufacturing Company
BU-120D	Pittsburgh Plate Glass Company

All traces of grease were removed from the metal parts by immersion in trichlorethylene.

The difference in wettability of the three adhesives on aluminum alloy 3003 and Berylco 25 were determined by means of a sessile drop that had been cured on each metal surface. The **contact** angle of the adhesive drops with each metal surface was compared by means of visual observation at 10X magnification using a binocular microscope.

Based upon this subjective comparison of the wettability of the metals by the adhesives, they were rated as noted below good, fair, or poor:

	Aluminum 3003	Berylco 25
EC-1469	poor	poor
EC-2258	good	good
BU-120D	fair	good

Tensile specimens were prepared by making 3/4" wide x 3" long specimens of aluminum 3003 and Berylco 25 bonded together with each of the three adhesives and cured at 325°F for 1/2 hour. The bonds were then subjected to 180° peel tests.

The EC-2258 adhesive bond was the only one that did not fail in the peel tests.

It appears significant that the EC-2258 epoxy, which rated good in the wetting and bonding tests and which passed the peel test gave the best bias stability so far obtained in an accelerometer that has been subjected to temperature sterilization. It may also be pointed out that the EC-2258 rated in the shear tests (See the following Section).

3.1.1.1.3 Shear Tests

(For more detail see Qu.R.2, Section 1.1.2 and Qu.R.3, Section 1.1.1)

The shear test specimens, as shown on page 5 of Qu.R.2, are designed to reflect the actual conditions in the accelerometer. Representing the pendulum supports are bars made of aluminum alloy 3003. One end of each bar is slotted to allow about 1/2 inch penetration of the Berylco 25 plates representing the springs. The areas filled with adhesive are indicated on the drawing, page 5.

The physical qualities of the bond are described by the rupture load, the rupture stress, the distribution of the adhesive remaining on the aluminum and/or on the Berylco 25 after rupture and by the widening of the slots in the aluminum parts.

The rupture load applied to each sample was directly measured.

The rupture stress was computed; the reference surface for the computation was taken as twice the product of the length L of the interface between the two metal parts and the thickness H = .20 inches of the aluminum part. The length L of the interface was not very accurately controlled by the building fixtures used to make the shear test specimens. For this reason, the length L was measured on each individual test specimen. The separated parts were inspected for the amount of adhesive remaining on the bonded metal surfaces. It was found generally that separation occurred either on the aluminum or on the Berylco 25 interface, but not parallel to these surfaces through the adhesive layer. In some cases, the adhesive was found to adhere in patches to the aluminum while the balance remained attached to the Berylco 25. In other cases, the adhesive was found to separate completely from either the aluminum or the Berylco 25. The distribution of the remaining adhesive was found occasionally to be very different on both sides of one and the same specimen even to the point where the adhesive would remain entirely attached to the aluminum on one side and to the Berylco 25 on the other side of the specimen. Listed in the tables containing the test results is the percentage - estimated by eye - of the remaining coverage of the bonding area on the Berylco 25 material for each side of the bar of which one side was arbitrarily designated as side A, the other as side B. This evaluation does not apply to the test specimens made with LCA-4/BA-9 epoxy and not subjected to temperature sterilization. In these specimens, the separation occurred mainly in the epoxy layer parallel to the bonding surfaces. A characteristic particular to the specimens made with the Scotchweld EC-2258 epoxy, a significant widening of the slot area in the aluminum parts after separation, was not found in other specimens.

Four specimens were made with each type of epoxy listed below:

BU-120D	Pittsburgh Plate Glass Company
Ablecast 147-1	The Ablestik Adhesive Company
EC-2258	Minnesota Mining and Mfg. Company
2850 FT/11	Emerson & Cummings
LCA-4/BA-9	Bacon Industries, Distributed by The Ablestik Adhesive Company

Two samples of each type were submitted to the temperature sterilization environment, 360 hours at 275°F. The results of the shear tests are listed on page 7 of Qu.R.2 and on page 5 of Qu.R.3 (the experimentation did not extend into the fourth quarterly reporting period).

It may be noted that the results obtained on specimen #5 (Ablecast 147-1) indicate that no bond at all was achieved; 40 lbs. is just the load needed to overcome the friction while separating the parts. In the following evaluation of the test results, specimen #5 has been disregarded.

The main observations that appear important in the correlation of the shear test results with the bias stability obtained before and after temperature sterilization in functional accelerometers are listed below.

Item 1. **In all cases, temperature sterilization has reduced the bond strength.**

Item 2. The bond strength of the EC-2258 epoxy was the least affected by temperature sterilization. This epoxy lost only 21% (average) of its bond strength, comparing to a loss of 41% in the case of Ablecast 147-1 and 51% in the case of LCA-4/BA-9.

Item 3. The EC-2258 epoxy showed the highest bond strength before as well as after temperature sterilization.

Item 4. Temperature sterilization tends to loosen the bond between the adhesive and the Berylco 25 material. The Ablecast 147-1 epoxy is the only exception.

Item 5. Generally, the bond breaks at the interface between the adhesive and the opposing metal part. The LCA-4/BA-9 epoxy marks the exception to this rule, but only before temperature sterilization.

Item 6. The specimens made with the EC-2258 epoxy showed an appreciable widening of the slot area in the aluminum part, both before and after temperature sterilization.

Attempts to correlate the shear test results with the bias stability observed in functional accelerometers are limited to three types of epoxy namely EC-2258, Ablecast 147-1 and LCA-4/BA-9.

After temperature sterilization, the accelerometer built with EC-2258 showed the best bias stability (See the following section 3.1.1.2) closely followed by that built with the Ablecast 147-1 epoxy. As stated before, the LCA-4/BA-9 bond deteriorates when exposed to an environment far less severe than that of temperature sterilization.

Items 2, 3 and 6 noted above tend to explain the superiority of the EC-2258 over the Ablecast 147-1 and the LCA-4/BA-9 epoxies after temperature sterilization.

Item 4 tends to favor the Ablecast 147-1 epoxy and may explain, why the post sterilization bias stability is not as much inferior to that obtained with the EC-2258 epoxy as the much lower bond strength of the Ablecast 147-1 epoxy would lead to expect.

Item 5 may explain the good performance obtained with the LCA-4/BA-9 epoxy in all programs not involving temperature sterilization or operating temperatures above 145°F.

3.1.1.2 Bond Evaluation in Functional Accelerometers

A certain type of testing, referred to as flip-flop testing has evolved as a method to evaluate the quality of the spring-to-support bonds of an accelerometer. To date, this method has been used exclusively on accelerometers featuring adhesives rather than soldered bonds. The development leading to the use of adhesives in the spring-to-support joints and to the application of the flip-flop soaks is described in detail in Bell Report No. 60002-440-1, Supplement No. 1, "Proposal for Design of a Sterilizable Accelerometer".

The flip-flop test used in the present program is described in Qu.R.2, pages 12 through 14. It differes somewhat from the original flip-flop test procedure: in previous programs hot soaks have alternated with cold soaks; in the present program hot soaks only are applied (8 hours at 160°F). During the hot soaks, the input axis is aligned with the direction of gravity but reversed 180° alternatingly from soak to soak so that, if a positive input direction is defined, the direction of gravity will coincide with the positive input direction in one soak (flip position) and will be in opposition (flop position) during the following soak. Six soaks constitute a complete test cycle. During the soaks no power is applied. All readings on the functioning accelerometer are taken after the instrument has stabilized at room temperature: The first readings before the first soak and other readings following each of the six soaks. The bias values thus determined are plotted in sequence. The line connecting the points representing the bias values generally emerges as a more or less regular saw tooth diagram. The bandwidth of this diagram furnished a measure for the quality of the bond. The effects of temperature sterilization on the bond are evaluated by comparing the bandwidth obtained after temperature sterilization to that obtained before temperature sterilization.

In Model IIIB-8 accelerometers built with LCA-4/BA-9 in the spring-to-support joints the bandwidth increased from a typical 250 μg to values up to 800 μg when the accelerometers were submitted to a postcure of 120 hours at 200°F, which is a mild environment compared to the temperature sterilization cycle of 360 hours at 275°F applied in this program. In recent investigations performed at JPL on Model VIIB-5 accelerometers, temperature sterilization resulted in a bandwidth of up to 1500 μg, as already mentioned in section 2 of this report.

In the present program the flip-flop soak test has been applied to evaluate two types of epoxies; namely, the Ablecast 147-1 and the Scotchweld EC-2258. Attempts to evaluate the Bondmaster 620 epoxy were abandoned because of difficulties encountered in the process of building of the accelerometers (for reference see Qu.R.1, page 6).

3.1.1.2.1 Ablecast 147-1

For details see Qu.R.1, pages 10 through 17. The graph showing the results of the flip-flop soak tests is contained on page 16 of Qu.R.2.

Following the preliminary tests, two temperature runs were performed on accelerometer M-225 which was built with the Ablecast 147-1 epoxy in the spring-to-support joints. The variation of null bias with temperature was found to be 2.64 micro g's per °F in the first run and 2.98 micro g's per °F in the second, which can be rated as good performance.

The bias values obtained during the following flip-flop soak test are listed on page 15 of Qu.R.2. The pattern is regular and shows a bandwidth of 240 micro g.

After the first flip-flop test cycle, the functional electronic assembly on accelerometer M-225 was replaced by a non-functional electronic assembly. This was done in order to avoid damage to the functional electronic assembly during temperature sterilization. Such damage could have affected the post-temperature-sterilization performance of the unit and thus obscured the effects under investigation of the temperature sterilization on the spring-to-support bond.

Unit M-225, provided with the non-functional electronic assembly was filled with Helium and hermetically sealed. The accelerometer was submitted to a temperature of 275°F for 360 hours. Then the functional electronic assembly was re-installed. Again two temperature runs were performed. The first showed a variation of

-4.7 micro g per $^{\circ}$F, the second practically zero variation. The poor repeatability was interpreted as a sign of deterioration of the bias stability as a consequence of the temperature sterilization.

The flip-flop soak test cycle performed thereafter resulted in a bandwidth of 555 micro g. Since the accelerometer has to meet the requirement that the null bias should not exceed the limits of ± 300 micro g, this result was not considered satisfactory all the more as the average of the null bias had shifted about 350 micro g from before to after temperature sterilization. The search for a better adhesive was continued. Based on the preselection tests the Scotchweld EC-2258 was chosen.

3.1.1.2.2 Scotchweld EC-2258

After the initial tests, two temperature runs were performed with accelerometer M-225 which had been rebuilt with Scotchweld EC-2258 epoxy in the spring-to-support joints. The average slope of -2.14 micro g per $^{\circ}$F is considered good performance. It was, however, observed that the return points to room temperature showed a rather large spread. (See Qu.R.3, page 7).

A flip-flop soak test cycle was then performed. The bias readings are listed in Qu.R.3, page 8, the graph showing them is contained on page 9. The pattern is not very regular and a bandwidth hardly definable. Tentatively a bandwidth of about 300 micro g could be suggested.

Immediately following the flip-flop soak tests a certain sticking of the pendulum to the capacitance rings was noticed. During the next days the accelerometer was under observation and the sticking condition was found to get worse. It was this happening that triggered the investigation described in section 3.3.1 of this report concerning the surface protection of the capacitance rings. The accelerometer was taken apart and the capacitance rings were cleaned. During the process of re-assembly, the springs were accidentally broken. Because the reference to the flip-flop soak test previously performed was lost, it was decided to repeat this test after rebuilding with new springs. Before the second flip-flop soak test was undertaken, two temperature runs were performed: the first before hermetical sealing of the accelerometer; the second after sealing to confirm proper performance of the accelerometer. The results are listed below in Table I.

TABLE I. VARIATION OF BIAS WITH TEMPERATURE IN UNIT M-225
After Rebuilding with New Springs

CONDITION		TEMPERATURE °F	BIAS µg	SLOPE µg/°F
Before Sealing	Start	76.0	-551	+2.25
	High	124.9	-550	+2.97
	Return	74.0	-591	
After Sealing	Start	74.2	-770	+3.44
	High	124.2	-598	+3.82
	Return	74.0	-790	

It appears that the hermetical sealing did not appreciably influence the performance of the accelerometer. The bias shift experienced was to be expected. It will be noted that before the rebuilding of the accelerometer an increase in temperature resulted in a negative bias drift, after rebuilding in a positive drift. The slope experienced after rebuilding is higher than the slope before rebuilding but it is still well within exceptable limits.

Following the temperature runs, accelerometer M-225 was subjected to a flip-flop soak test cycle. The results are listed below in Table 2. The graph, page 30 shows the corresponding sawtooth diagram.

TABLE 2. FLIP-FLOP SOAK TEST RESULTS
(Before Temperature Sterilization)

	BIAS IN μg
Before the first "Flip" soak	-1489
After the first "Flip" soak	-1636
After the first "Flop" soak	-1446
After the second "Flip" soak	-1661
After the second "Flop" soak	-1485
After the third "Flip" soak	-1701
After the third "Flop" soak	-1462

The above results may be compared to those obtained before the rebuilding of the accelerometer with new springs.

The flip-flop diagram is much more regular after rebuilding. The bandwidth of 255 μg is comparable to that obtained with the Ablecast 147-1 epoxy in the spring-to-support joints. (See Monthly Technical Progress Report No. 5, page 3).

The bias at room temperature after the second temperature run was -790 µg; the bias before the first "flip" soak was -1489 µg, which constitutes a bias shift of -699 µg. This is a rather high change even considering that the temperature runs and the flip-flop soaks were performed on different test stations. It was, however, decided to continue the flip-flop soak tests once they had started in order to avoid a further disturbance of the accelerometer.

It was initially intended to determine experimentally how much the change of station contributed to the change of null bias. This experiment, however, could not be carried out because the electronic assembly E7 failed, as will be seen, in temperature sterilization, and the reference was lost. The electronic assembly #7 was left attached to the mechanical assembly M-225 during temperature sterilization in the hope that it would survive and that the time involved in replacing E7 by a non-functional assembly and in re-installing

E7 could be saved. For the case of failure the standby electronic assembly H6 was held ready.

When testing of accelerometer M-225 was resumed after temperature sterilization it was found that the electronic assembly E7 had indeed failed. It gave no output. Inspection showed that the collector resistor of the type RN55D was open. After replacement of this resistor the electronic assembly still did not function and it was replaced by the backup unit H6. The post mortem of unit E7 will be reported on in section 4, Electronic Assembly, of this report.

The bias readings taken during the flip-flop soak test cycle performed after temperature sterilization are listed in Table 3 below:

TABLE 3. FLIP-FLOP SOAK TEST RESULTS
(After temperature sterilization)

	BIAS IN μg
Before the first "Flip" soak	-826
After the first "Flip" soak	-952
After the first "Flop" soak	-512
After the second "Flip" soak	-965
After the second "Flop" soak	-603
After the third "Flip" soak	-882
After the third "Flop" soak	-605

The bias points are plotted in the graph page 30, the same in which the pre-sterilization results are shown. The bandwidth of 453 micro g after sterilization compares favorably with that of 555 micro g obtained with the Ablecast 147-1 epoxy. However, in view of the stability requirements of this program, the 453 micro g bandwidth can be only considered as just marginal.

Concluding the report on the application of the Scotchweld EC-2258 epoxy it may be mentioned that at first some difficulties were encountered in attaching the springs to the pendulum supports. The first attempt failed. During the second building of the accelerometer the improved method proved successful as was

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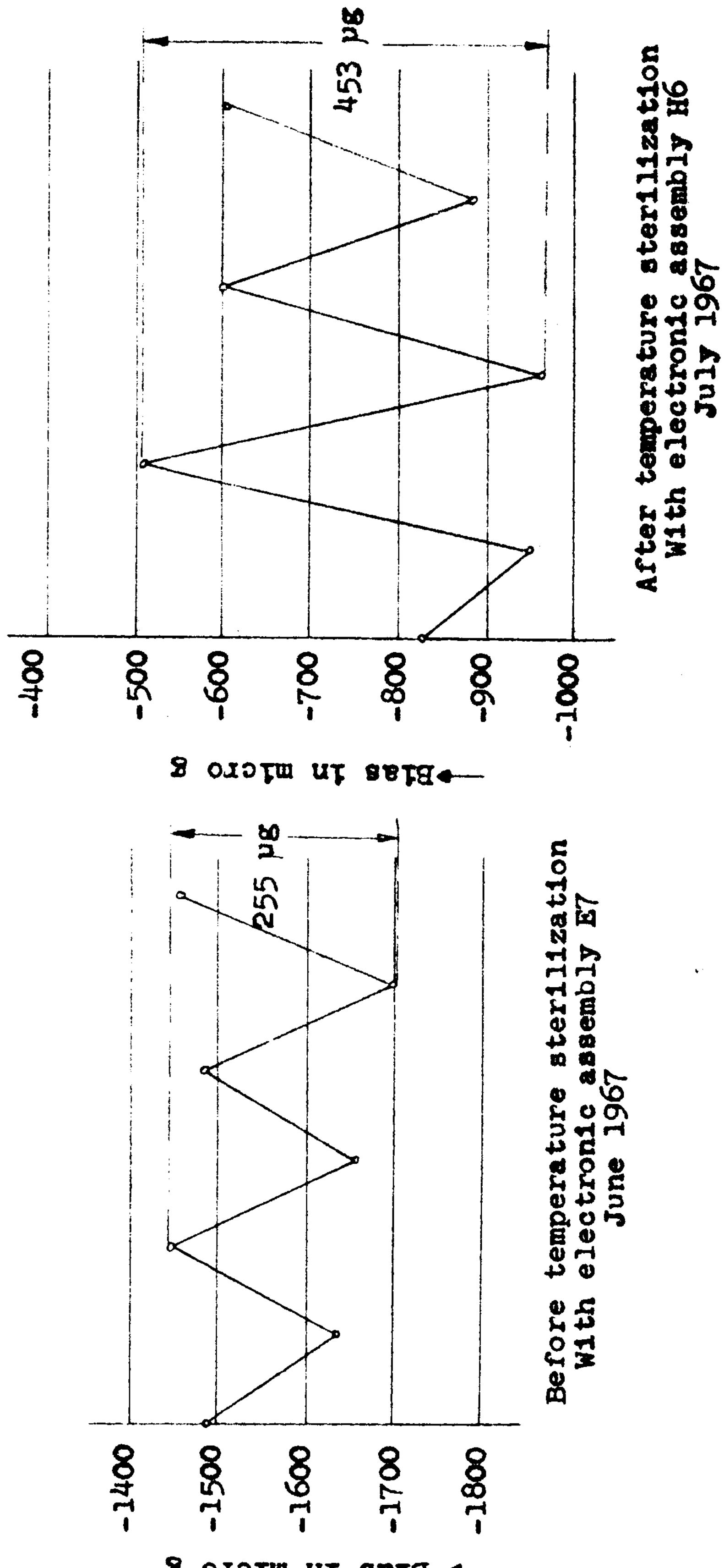
Accelerometer M-225
Flip-Flop Return Points
Epoxy in Spring-to-Support Joints: Scotchweld EC 2258



demonstrated during two further rebuildings, the first of which was needed because the torquer coil windings failed, the second because of the accidental breaking of the springs mentioned above. The failure of the torquer coil windings is reported on in detail in section 3.2 of this report.

3.1.2 Laser Welding

Supplement No. 1, Appendix 2 of Bell's "Proposal for Design of a Sterilizable Accelerometer", Bell Report No. 60002-440-1 outlines some ideas concerning a pendulum designed for laser welding of the junction from the spring tabs to the pendulum supports. This approach was suggested because it is anticipated that a metal to metal junction will yield a better bias stability than an adhesive joint.

The corresponding part of Bell's proposal was not included in the present program. However, when Bell was offered the opportunity to perform some laser welding at the George Marshall Space Flight Center, an object was chosen for these experiments that promised to render some indications concerning the feasibility of the laser welded spring joint and that, in addition, offered the possibility to eliminate the application of an adhesive in the pendulum area, namely the securing of the pendulum supports to the torquer coil form. The corresponding efforts are described in Qu.R.3 pages 14 thru

18, where all aspects are covered in detail. Only the essentials are repeated here.

The pendulum frame is of composite design. Each pendulum support is provided with two prongs that are riveted into holes in the coil form. The connection between the supports and the coil form is reinforced by epoxy which is applied to the seams at the junction of the supports and the coil form. The laser welding was applied to the seams in an effort to make this a metal-to-metal junction.

As a first step, a schedule was established giving best results on the material involved, namely aluminum. This schedule is as follows: Pulse time 5 milliseconds, weld diameter .020 inch. The voltage was varied between 1475 and 1550 volts. The laser welder used is of the type LMT-21.

Experiments were conducted on some parts that were rejected for dimensional out of tolerance conditions not affecting the welding. The quality of the weld joints was determined by visual inspection only.

Conditions under which satisfactory results would be obtained were established. Some modifications in the design of the supports in the junction area appear indicated. Introduction of laser welding in the present program is not considered. A conclusion concerning the applicability of laser welding to the junction of the springs to the supports was not arrived at.

NOTE: Concerning the Balance of Problem Areas in the Mechanical Assembly

The above report on the attempts at laser welding concludes the description of the efforts made in the area of the spring-to-support bond which, as already stated, represents the most involving single item in the area of the mechanical assembly. The balance of problem areas of the mechanical assembly is divided into two main groups according to the type of material involved.

Section 3.2 deals with the nonmetallic materials, section 3.3 with the metals. The deposits observed are all believed to be nonmetallic and are reported on in section 3.2.

The actual investigation of both groups of materials was conducted simultaneously as follows:

As a first step, Bell provided JPL with a Product Bill of Material listing all the parts and materials used in the original Model VIIB-5 accelerometer. JPL has checked this Bill of Material and identified those materials that are either objectional or undesirable, or that could be replaced by better suited materials.

As a next step, JPL has furnished to Bell three specifications which Bell has used to identify replacement materials. These specifications are:

> JPL Spec. WR 500304
> Polymeric and other nonmetallic materials, Preferred
>
> JPL Spec. WR 500305
> Metals, Preferred

JPL Spec. WD 500306
Process Specifications, Preferred

In further steps to identify problem areas, Bell has submitted two accelerometers of original design to the environment of temperature sterilization. Instead of performing six soaks of sixty hours each one continuous soak of 360 hours at 275°F was applied. Both accelerometers were hermetically sealed and filled with helium. The accelerometers were opened up and visually inspected for the effects of the temperature sterilization. It appears noteworthy that the findings on both accelerometers were mainly identical.

The observations made on the two accelerometers helped to identify materials requiring replacement and to show up problem areas such as the appearance of deposits which had not shown up before temperature sterilization was applied. Where applicable, replacement materials were selected from JPL Spec. WR 500304 and some experimentation carried out.

All the information thus obtained was used to determine the configuration of the mechanical assembly of accelerometer M-225 which, besides being used to evaluate the Scotchweld EC-2258 epoxy, was used as a carrier for experimentation with replacement materials. At the end of the reporting period, the accelerometer M-225 was not available for disassembly and inspection, so that the corresponding results are not yet known. The functional tests performed on accelerometer M-225 gave no indication of any disturbances in the area of the mechanical assembly through temperature sterilization other than the increase of the flip-flop bandwidth reported on in section 3.1.1.2.2. This increase is believed to be unrelated to the items listed in the sections 3.2 and 3.3.

3.2 Nonmetallic Materials

For details see Qu.R.1, pages 11 through 18 and Qu.R.2, pages 17 through 22.

The investigation of the nonmetallic materials is reported on in two sections. The first, section 3.2.1 covers the deposits; the second, section 3.2.2 covers the material investigation proper.

It is noted, that it has not been possible to link the deposits to any particular type of nonmetallic material used in the accelerometer. It is hoped that the replacement of objectional or questionable materials will eliminate the deposits. How far this condition has been achieved in accelerometer M-225, which in its latest configuration contains numerous replacement materials, is not yet known.

3.2.1 Deposits

As mentioned before, the deposits have been observed in accelerometers of original design that were submitted to a temperature of 275^{o} for 360 hours. Both accelerometers were hermetically sealed and filled with helium.

The first type of deposit was found only in one of the two accelerometers. This deposit is smooth, white transparent, and sticky. It was found on outer surfaces of the magnet housings and would not impair the performance of the accelerometer. It is believed to be a remainder of flux and that thorough cleaning would avoid its appearance.

The second type of deposit settled mostly on copper containing metal parts, giving them a shiny appearance. This deposit was observed in both accelerometers. It did not appear on the brass capacitance rings contained inside of the magnet assemblies, which indicates that its source lies outside of the magnet assemblies. This deposit, too, could be due to remains of flux. It, also, would not impair the performance of the accelerometer.

The third type of deposit could, if buildup continued, lead to a catastrophic failure. It is white opaque and granular. It was found mainly in the airgap of the magnetic flux path, namely on the I. D. of the magnet housing and on the O. D. of the aluminum coil form. It appears mostly on that part of the I. D. of the magnet housing that is opposite to the coil windings of the pendulum. The I. D. of the coil form and the O. D. of the flux plates remained free of the deposit, the grain size of which generally is between .001 and .003 inch. In the area between the I. D. of the magnet housing and the O. D. of the torquer coil form this is nearly enough to bridge the airgap. It is suspected that the deposit originates from the FFA-2 epoxy applied to the torquer coil windings. In the latest configuration of accelerometer M-225 this epoxy has been replaced by Epon 828 Z which is listed among the preferred materials in JPL Spec. WR 500304. Inspection of this accelerometer is pending.

In one accelerometer a further type of deposit was observed in the same area as the white opaque granulated deposit, namely an extremely thin even coverage of light brown which did not appear to be rust. This deposit would not affect the accelerometer performance. From the color of the deposit it was felt that its origin could be the isonel type 155 magnet wire insulation. In the rebuilding of accelerometer M-225, magnet wire isolated by heavy isonel type 200 has been used. This insulation is rated for 185°C (365°F) by the manufacturer.

3.2.2 Nonmetallic Materials Proper

The sequence of the materials listed below is not systematic except that those showing a high degree of deterioration are listed first. In all cases, the JPL rating is indicated. For evaluation of the effects of temperature sterilization on the nonmetallic materials, visual inspection and subjective evaluation properties as stickyness or brittleness have been applied. It is recognized that visually detectable deterioration alone is not a valid criterion for the acceptance or rejection of a material since other areas such as outgassing are not covered. For this reason, Bell has made efforts to replace a material not contained in JPL's list of preferred materials by a JPL preferred material, even if no visible signs of deterioration are found. Where applicable, the results of experimentation with replacement materials are given and the replacement materials used in the latest configuration of accelerometer M-225 are named.

3.2.2.1 Tuf-On 747-S

JPL rating: Objectional

This material is applied to cover that part of the surface of the magnets remaining free after the magnets are rolled in and the flux plates are attached. This is done to prevent tiny particles that could be relatively loose in cracks and pin holes from breaking loose and finding their way into the airgap by magnetic attraction.

The Tuf-on, originally a clear material, was found to be completely discolored to brown or gray depending upon the thickness applied.

In an effort to identify a replacement material some experimentation with Epon 828 Z was conducted. A thin film of this material was applied to two magnets which were subjected to a temperature sterilization cycle of 360 hours at 275°F. The Epon 828 Z film was found to be discolored to a brownish hue; however, it did not show any tendency to flake off. When applied to the magnet surfaces the epoxy was clear and it was then hard to see if all bare areas were covered. The discoloration showed that this was not the case. It appears that a material with a better whetting action would be preferable. Until such a material is identified, it is planned to apply Epon 828 Z in these areas of the magnet surface showing crevices or pinholes. The surfaces would be left bare if close inspection shows that they are free of flaws.

3.2.2.2 #5 Electrical Tape (3M)

JPL rating: Objectional

This tape is used to cover through holes in the interior of the magnet housings to prevent penetration of foreign matter. After temperature sterilization the tape was found to be very brittle but still clinging to the magnet housing by means of the adhesive which remained sticky. In one of the two accelerometers investigated the adhesive appears to have softened under the influence of heat and to have flowed together in the hole areas. It appeared further, that the thickness of the tape proper had been reduced.

As a substitute material the Mystik tape 7352, which is listed on page 28 of JPL Spec. WR 500304, was selected for experimentation. A sample of this tape was applied to the outside of one magnet housing of accelerometer M-225 when this unit was rebuilt for the evaluation of the Ablecast 147-1 epoxy. Inspection showed that the tape had partially separated from the magnet housing and had lost its adhesive qualities where separated from the magnet housing. This test was not considered conclusive because the sample might have been overaged. For confirming, accelerometer M-225, in its latest configuration has been rebuilt with a new batch of the Mystik tape 7352; the tape was applied to the interior of the magnet housings. Inspection after temperature sterilization has not yet been performed.

3.2.2.3 #55 Electrical Tape (3M)

For reference see Qu.R.2, page 22, Evaluation of Mystik Tape 7300.

JPL rating: not listed.

The electrical tape #55 is used on the outside of magnet housings to cover peep-holes allowing observation of the pendulum alignment. The Mystik tape 7300, also listed in JPL Spec. WR 500304, was selected as a replacement. A sample, which also might have been overaged, was subjected to temperature sterilization along with the Mystik tape 7352 in accelerometer M-225. Inspection after temperature sterilization revealed that the tape had separated into two components: the tape proper and the adhesive. The tape proper was found to be very brittle. Accelerometer M-225, in its latest configuration, contains a sample of the 7352 tape taken from a new batch of material. The effects of temperature sterilization still remain to be investigated.

3.2.2.4 Nylon

JPL rating: objectional

This material has been used for spacers placed between the magnet housings and the top cover of the accelerometer. The purpose is to limit the tilt of the top cover. Visual inspection after temperature sterilization did not disclose any signs of deterioration. In the present design of the sterilizable accelerometer, the spacers are no longer used.

3.2.2.5 Formvar Insulated Wire

JPL rating: Not desirable

The wire is used to connect the ends of the torquer coil windings to the spring tabs. Visual inspection after temperature sterilization revealed no signs of deterioration. The magnet wire insulated with heavy Isonel type 200 will be used to replace the Formvar insulated wire. Accelerometer M-225 in its most recent configuration contains the heavy Isonel type 200 wire. The replacement of the Formvar insulated wire by Formex insulated wire (See Qu.R.2, page 20) is no longer considered for reasons explained in section 3.2.2.7 of this report.

3.2.2.6 Polyolefin

JPL rating: Not desirable

RNF 100 heat shrinkable sleeving is used to provide stress relief in the area where the capacitance leads are attached to the capacitance rings. Visual inspection after temperature sterilization revealed no signs of deterioration.

Rayclad Kynar shrinkable tubing, listed on page 26 of JPL Spec. WR 500304, was selected as a replacement material. Experimentation including exposure to the temperature sterilization environment was performed and showed satisfactory results. For reference see Qu.R.3, page 14, section 1.2.4.

Accelerometer M-225 in its latest configuration contains the Kynar tubing. Inspection and evaluation is pending.

3.2.2.7 Isonel Wire Type 155

JPL rating: Not listed

This wire is used in standard VIIB accelerometers to wind the torquer coil. (Transition to Isonel type 200 is underway).

Post sterilization inspection performed on the first accelerometer involved revealed no sign of deterioration. In the second accelerometer the surface of the winding looked less shiny than before temperature sterilization. The Isonel type 155 insulated wire is rated at 275°F by the manufacturer, which is marginal.

It was decided to rebuild accelerometer M-225 with Formex insulated wire (see JPL Spec. WR 500304, page 31). As reported in Qu.R.3, page 10, the coil wound with the Formex insulated wire failed when the pendulum assembly was rebuilt with the Scotchweld EC-2258 epoxy in the spring-to-support joints. This epoxy requires a cure of 1 hour at 350°F. The failure of the coil was evidenced by a change in resistance of the torquer coil from 14 ohm before the curing of the EC-2258 epoxy to 6 ohm after the curing.

At this point, it was decided to rebuild the torquer coil with Isonel type 200 wire which was available in house. This wire is rated at 365°F by the manufacturer.

Accelerometer M-225 was accordingly rebuilt and has since undergone temperature sterilization without failure of the torquer coil. Inspection of the torquer coild for possible effects of temperature sterilization is pending.

3.2.2.8 FFA-2 Epoxy (Bacon)

JPL rating: Not listed

This epoxy was selected for the application to coil windings which are located in an inner groove of the coil form. (See Qu.R.1, page 15) The FFA-2 epoxy has also been used to secure the coils wound on coilforms with outer grooves. This was the case on the two accelerometers of original design which were submitted to temperature sterilization. No adverse effects on the windings, however, the FFA-2 epoxy is a prime suspect as source of the white opaque granulated deposit found in the magnetic airgap of the accelerometer.

When the accelerometer M-225 was rebuilt to its latest configuration, Epon 828 Z was used to secure the torquer coil windings in the coil form groove. It remains to be seen if the application of the Epon 828 Z epoxy has eliminated the white opaque granular deposit.

3.2.2.9 Locktite, Grade A

JPL rating: Acceptable, but not desirable

This material is used to secure screws, either in the thread or at the head, or both. After temperature sterilization all screws were found still secured but it has been possible to loosen them with an adequate torque. No signs of deterioration were detected. Replacement materials have not been evaluated to date.

3.2.2.10 Epon 828 D

JPL rating: Not listed

In standard Model VIIB accelerometers, Epon 828 D is applied for two purposes: first, to attach the flux plate to the magnets; second, to bond the Diamonite insulators to the base plate and to the spring clamps. Especially the latter application requires resilience of the bonding material (for reference see Qu. R. 1, pages 16 thru 18 and Qu. R. 3, section 1.2.2).

In an effort to replace the Epon 828 D by a JPL recommended material, accelerometer M-225 has been rebuilt with Epon 828 Z in the above named applications. Epon 828 Z is listed on page 5 of JPL Spec. WR 500304. No adverse effects of this change have been noticed during the fabrication of the accelerometer, specifically during the grinding operation performed on the Diamonite insulators after their bonding to their carriers. The performance of the accelerometer before and after temperature sterilization does not indicate any other adverse effects.

Inspection of the subassemblies in which the Epon 828 Z was applied for possible visible effects of temperature sterilization is pending.

3.3 Metals

The experimentation with the two accelerometers of original design has shown that metallic parts were unaffected by temperature experimentation except for slight discolorations which were observed mainly on nickel plated soft iron surfaces and on some brass parts. It is felt that instrument performance could not have been affected by these changes.

One incident, already mentioned in section 3.1.1.2.2 of this report, namely the sticking of the pendulum in accelerometer M-225 is felt to be associated with the brass used in capacitance rings. Sticking of the pendulum has been observed on rare occasions in other programs and may, if not caused, at least be accelerated by temperature sterilization. In former cases a very slight outgrowth on the capacitance rings was observed, and this outgrowth is believed to be due to the impurity of the brass; removal of the outgrowth has remedied the sticking situation.

There is also the possibility that the sticking is caused by a deposit on the capacitance rings. Actually, no such deposit has been seen on the capacitance rings of the two accelerometers of original design that were subjected to temperature sterilization. Further, it is felt that the introduction of JPL preferred nonmetallic materials will reduce the tendency - if it ever existed - of the formation of deposits. For this reason, emphasis is placed on the metal side of the investigation.

Efforts are underway in a company funded program to avoid the sticking of the pendulum by making the capacitance rings out of titanium rather than brass.

Two accelerometers have been equipped with titanium capacitance rings. However, a problem arose, namely to produce a proper connection of the capacitance leads to the capacitance rings. This problem has not yet been solved.

Instead of using titanium, it is contemplated in the immediate application to the sterilizable accelerometer to apply surface protection to the brass capacitance rings. This involves new steps in the accelerometer assembly procedure. These new steps are explained below:

In the magnet housing-capacitance ring assemblies of the standard Model VII accelerometers, the distance between the pick-off surface of the capacitance ring and the reference surface of the magnet housing is controlled within ± 50 micro inch. In order to obtain this high accuracy, the pick-off surface of each capacitance ring is machined while the capacitance ring is installed in the magnet housing. It is after this machining operation that the surface protection would have to be applied to the capacitance ring. Removal of the capacitance ring from the magnet housing is felt to be mandatory for the process of surface protection. Care would have to be taken to assure that in the process of re-assembly, the pick-off surface of the capacitance rings is restored accurately to its position after machining. A procedure to obtain this result has been established: the three jewel washers used as spacers between the capacitance ring and the magnet housing are bonded to the magnet housing, e.g., by means of an epoxy, so that their position does not change when the capacitance ring is removed. In accelerometers of present design, the jewel spacers are held in position by friction only. The capacitance rings on standard Model VII accelerometers are not removed after machining of the pick-off surface. When the suggested procedure of removal and re-assembly is applied, it will evidently be necessary to re-inspect the magnet housing-capacitance ring assembly to assure proper positioning of the pick-off surface.

The corresponding development program was performed during the fourth quarterly reporting period. It involved two phases: first, the identification of an adequate surface protection procedure; second, the application of the assembly procedure described above to an actual magnet housing - capacitance ring assembly. In both phases the effects of temperature sterilization were evaluated. The first types of surface protection experimented with were products of the Hanovia Liquid Gold Division of Engelhard Industries, Inc. namely:

Liquid Bright Gold	Number 6854 and
Liquid Bright Platinum	Number 05

The results obtained on the brass capacitance rings were not satisfying. The fluids were applied by brush. After firing the coating was found to be uneven and bright only in limited areas. Since even coating is essential to maintain the proper position of the pick-off surface after re-installation of the capacitance ring, these efforts were discontinued.

Next, a chromating process was applied rendering an even shiny surface which will readily accept 60/40 SN 60 solder.

Further, a process of electroless gold plating was used. The chemicals were obtained from Technic, Inc. The process is designated as Oromerse, Immersion 24 KT Gold. According to information from the supplier, a coverage of 3 μ inch builds up in about 15 minutes. Further submersion adds only very little to the film thickness. Two capacitance rings were accordingly treated and placed into an oven at 275°F where they remained for 360 hours.

It may be mentioned that the capacitance rings used for the above experimentation were parts which, in other programs, had been rejected for being dimensionally out of specification.

The chromated parts and the parts plated with Oromerse were subjected to temperature sterilization. The chromated parts were found to be discolored to a dull dark brown. The two capacitance rings treated with Oromerse appeared unaffected by temperature sterilization; their surfaces looked bright and shiny.

The complete assembly procedure involving the bonding of the jewel spacers to the magnet housing, removal of the capacitance ring and re-assembly after surface protection of the capacitance ring was tried out on a subassembly comprising the magnet housing with the serial number S-40B. The surface treatment involved was electroless gold plating, Oromerse. The rebuilt subassembly was put into a temperature sterilization cycle.

Four sets of measurements - each comprising three points - were taken to determine the position of the pick-off surface with respect to the reference surface of the magnet housing: a first set providing reference values; a second set after bonding of the jewel spacers to the magnet housing, whereby the capacitance ring still remained attached to the magnet housing and, finally, a third set after re-installation of the surface treated capacitance ring. A fourth set was taken after the temperature sterilization cycle was completed.

Fig. 1 LOCATION OF CHECKPOINTS

Housing Serial No.

Type of Surface Treatment:

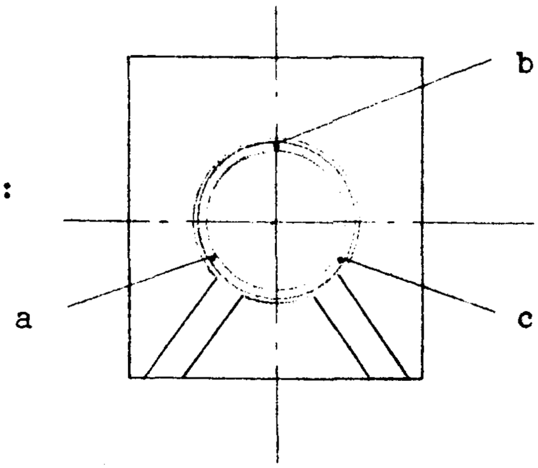


Table 4 PICK-OFF SURFACE DROP READINGS

Checkpoint	Set No. 1	Set No. 2	Set No. 3	Set No. 4
a	.08137	.08141	.08140	.08135
b	.08135	.08138	.08145	.08136
c	.08145	.08145	.08145	.08145

Set No. 1 Initial measurements after machining of pickoff surface.

Set No. 2 After Bonding of jewel spacers to magnet housing.

After set No. 2 of readings is taken, the capacitance ring is removed from the magnet housing. After surface treatment the capacitance ring is re-installed in the magnet housing.

Set No. 3 After re-installation of capacitance ring.

Set No. 4 After temperature sterilization (on experimental test samples only. Does not apply to deliverable accelerometers).

The three points at which the position of the pick-off surface with respect to the reference surface of the magnet housing was measured are shown in Figure 1, page 49. The results are listed in Table 4.

As was to be expected, the bonding of the jewel spacers to the magnet housing did not very much affect the position of the pick-off surface as a comparison of the results of Set #2 to those of Set #1 shows. After re-installation of the capacitance ring, Set #3, the pick-off surface was found to be about 40 μ inch (average) lower than in its initial position according to Set #1. This could be due to minute particles settled between the shoulder surfaces of the capacitance ring and the jewel spacers. Uneven coating of the capacitance ring is ruled out because the film thickness should not exceed 3 μ inch.

The drop from the magnet housing reference surface to the pick-off surface is to be within the limits of .0814" and .0815". It appears that in the position of Set #1 the pick-off surface location was out of specification by 30 μ inch at 2 points (both points are too high). The original inspection record dated 1-12-1965 indicated a low point with a drop of .08150" and a high point with a drop of .08145". The difference between the two sets of readings is not explained. It should, however, be noted that the accelerometer of which the magnet housing-capacitance ring assembly formed a part was subjected to a temperature sterilization cycle between the two sets of measurements. After re-installation of the capacitance ring the drop is within specification which, however, appears to be incidental, as is indicated by the readings Set No. 4, taken after temperature sterilization, which show that the capacitance ring has, for all practical purposes, regained the position it had before the procedure was started (see Set #1).

It is intended to apply the above procedure, involving Oromerse protection or equivalent, to the deliverable accelerometer.

4. Electronic Assembly

The main efforts in the area of the electronic assembly were directed toward the definition of a configuration expected to withstand temperature sterilization. The defining stage culminated in a design review, which was followed by parts procurement and the building of prototypes of the bridge transformer as well as of improved electronic assemblies of which one was completed and a second lacking only a variable capacitor

Experimentation involving temperature sterilization has not yet been performed on the improved electronic assembly or on subassemblies. Unexpected difficulties were encountered with the variable capacitors. Of four delivered, two were broken during installation and it was decided not to use any of the four in this program. Delivery of new parts is not expected before late August 1967. The only complete electronic assembly was provided with a variable capacitor transferred from the LEM Program.

An electronic assembly of original design, E7, failed in temperature sterilization (360 hours at 275^{o}F); the collector resistor and the transformer were found to be damaged.

The design review mentioned above represents a major part of the work performed in the area of the electronic assembly. It goes into very much detail covered in 50 pages. The following is intended to give a short summary.

4.1 Design Review

For full details see Qu.R.3, pages 19 thru 68.

The design review covers mainly those areas requiring redesign in order to meet the JPL Sterilization Requirements.

It describes the basic design of the electronic assembly, the main components of which are listed on page 20. They are: the upper half fixed bridge capacitors, the pick off transformer and the preamplifier.

4.1.1 Fixed Bridge Capacitors

The criteria for selection of these components are explained on pages 21 and 64. Besides the capability of withstanding temperature sterilization, these capacitors have to be selected for very close tracking characteristics, particularly in temperature coefficients.

4.1.2 Pickoff Transformer

This transformer has received very detailed coverage in the design reviews (see pages 23 through 45). Pages 35 through 45 are dedicated to a pictorial description of the manufacturing steps. Performance characteristics are discussed on pages 23 through 27. A unique feature of this transformer is its center tap primary which is incorporated to bleed static charges of the capacitance rings to ground by means of a bleeding resistor. The reasons why this design is felt to be preferable to a configuration applying two bleeding resistors are given on page 27.

In way of materials replacement, the electrical tape #27 (3M) formerly used is replaced by Mystik Tape 7020 (listed on page 28 of JPL Spec. WR 500304); the heavy Isonel type 155 insulation is replaced by the heavy Isonel type 200 insulation on the magnet wire; the potting compound Stycast 2850FT will be used with catalyst #11 rather than the catalyst #9 as listed on page 14 of JPL Spec. WR 500304. Performance specifications before and after potting are given on page 32.

5. Program Schedule

At the end of the third quarterly reporting period, the program was reported slipped for about 3 weeks. The slippage has increased to about 3 months at time of reporting due to the sticking of the pendulum and the accidental breaking of the springs in accelerometer M-225 during the evaluation of the Scotchweld EC-2258 epoxy. Not only did the accelerometer have to be rebuilt with new springs but the flip-flop soak test performed before the springs were broken had to be repeated. The tasks still remaining to be performed in the program are the establishment of the final configuration of the deliverable accelerometer, the building and testing of the same according to Article 1, Section (a) (4) of the Contract No. 951492. Coincidental with the above delays, readjustment of scheduling and immediate work objectives has been accomplished leading toward the recognition of the expanded scope of work as outlined in the recently negotiated amendment to the contract.